Regulation of the Wind Power Production: Contribution of the Electric Vehicles and Other Energy Storage Systems

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Introduction

The increasing penetration of renewable energy sources (RES) introduces additional difficulties in the design and operation of the power systems, mainly due to the high time-variability of these renewable resources, their non-dispatchability and the poor correlation with load profiles. In order to reduce negative impacts for the power systems while maximizing the penetration of RES - especially in power systems with a high renewable contribution as the Portuguese system - it is necessary to provide the system with means to regulate this highly variable power source that normally already exceeds the load consumption during wet and windy no-load periods.

Aims:

- To evaluate the excess of wind power (and other non-dispatchable) production, during periods of excess renewable generation in the year 2020, considering three weather design scenarios;
- Determine the adjustment of the profile of the wind production to the consumption;
- Determine the storage capacity (Pumping and Electric Vehicles (EV)) and possible surpluses;
- Analyze the cost/benefit of using storage units in power systems for the regulation of wind energy generation.

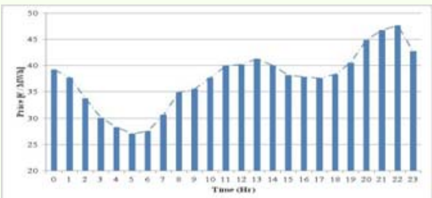
Methodology

The data series of the Portuguese power system, between 2004 and 2010, were analyzed in different scenarios.

Scenarios for the Portuguese power system in 2020

Three scenarios were built for the profile generation of the Portuguese power system in 2020. These scenarios were:

I. An extreme scenario regarding the wind a hydro power production (extreme RES scenario);
II. An extreme scenario of wind power production and medium hydro power production (extreme wind scenario),
III. An extreme scenario of hydropower production and average wind production (extreme hydro scenario).



Daily price profile in 2010 for the Portuguese electric market.
Source: Junior, 2011.

Each of these scenarios contains the following series:

- Loads;
- Loads together with EV loads;
- Loads together with EV loads and pumping.
- Run-of-River (ROR) hydro power production;
- Wind power production;
- Others non-dispatchable (including series for: independent thermo, small hydro and photovoltaic power);
- Dispatchable production;

With these data it was calculated the excess energy regulated by the storage units (EV and storage reservoirs with pumping (PHS)) determining in this way the reduction of the initial surplus.

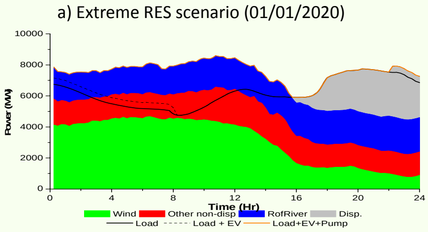
The work enabled to perform an economic analysis of the energy surplus from non-dispatchable sources; determining the value of the curtailed energy. The source data was obtained from OMIP (The Iberian Energy Derivatives Exchange) in 2010.

Results

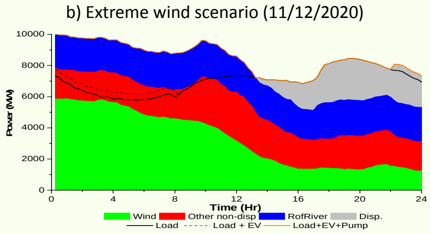
Analysis of the days with the highest penetration rate of non-dispatchable production

Daily profile of the power system for the day of 2020 with the higher penetration of non-dispatchable production for three wind/hydro scenarios.

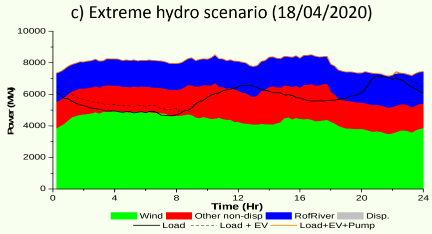
a) Extreme RES scenario (01/01/2020)



b) Extreme wind scenario (11/12/2020)



c) Extreme hydro scenario (18/04/2020)



Annual analysis

Surplus energy produced by non-dispatchable production; value, maximum power, EV load and pumping for 2020, in the considered scenarios.

		Excess	Consumption by EVs	Pumping
Extreme Scenario	Máx. Power excess(MW)	3 357	-	-
	Energy (MWh)	1 156 261	263 305	892 956
	Value (€)	19 939 634	4 611 705	15 327 929
Extreme wind scenario	Máx. Power excess(MW)	3 876	-	-
	Energy (MWh)	1 051 503	187 458	864 045
	Value (€)	27 174 204	4 463 362	22 710 842
Extreme hydro scenario	Máx. Power excess(MW)	3 428	-	-
	Energy (MWh)	823 671	173 314	650 357
	Value (€)	19 655 014	3 830 840	15 824 172

Annual analysis of no-load period

Surplus energy produced by non-dispatchable production in the no-load period (22.00H – 08.00H); transfer to the peak period using PHS, annual value in 2020, for the considered scenarios.

		Excess in no-load (22H – 08H)	Transfered (stored) energy (20H-22H)	Added Value
Extreme Scenario	Energy (MWh)	820 857	533 557	-
	Value (€)	13 158 508	23 269 008	10 110 500
Extreme wind scenario	Energy (MWh)	646 886	420 476	-
	Value (€)	16 205 503	20 413 260	4 207 757
Extreme hydro scenario	Energy (MWh)	520 788	338 512	-
	Value (€)	10 756 683	13 990 551	3 233 868

Conclusions

The expected increase of wind power penetration by the end of the decade, together with the daily profile of generation of this renewable energy source in some European regions, will contribute to an increase in power production during no–load periods; this scenario will represent a relevant surplus of renewable energy during windy wet winters.

This study showed that power regulation based on the distributed storage of EVs may have a relevant contribution for the absorption of the excessive energy delivered by the non–dispatchable fleet. Although important, EVs are not fundamental, since the maximum power surplus in the three scenarios will not exceed the PHS capacity planned for the 2020 timeframe.

Not taking into account market strategies and procedures, under MIBEL (Iberian Electricity Market), this study showed an added value brought by daily regulation, that may ensure the profitability of new PHS power plants.

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